Historical Pigments and the Role of Alchemy in their Production: an Interdisciplinary Study

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ABSTRACT: The aim of this study is to establish the relationship of alchemical practices regarding the fabrication of materials made available to artists during the medieval and the early Renaissance periods. Cennino Cennini (*Il libro dell'arte*, c. 1400) asserted that some basic pigments were "made by alchemy", his claim is relevant to my recent collaboration with the Croatian Conservation Institute on their publication *Tajne o bojama* (*Segreti per colori*) in which the authors consulted, for clarification of ancient recipes, *Alkemija* (by academician Drago Grdenić), the first work of its kind written in Croatian. In addition, a specific recipe published in an earlier manuscript of the 12th century, ascribed to monk Theophilus (1070–1125), will be examined as an illustration of alchemical writings deemed in most older literature to be incoherent text. Unintelligible texts encountered in old treatises deserve to be reconsidered within their historical context and, once deciphered, may reveal themselves to be viable recipes. Finally, alchemy's low esteem among scholars, especially scientists, merits a lengthier introduction and clarification.

KEYWORDS: *alchemy, pigments, laboratory equipment, Theophilus, Cennino Cennini, Trismegistus*

"...even when we find not what we seek, we find something as well worth seeking as what we missed."

Robert Boyle, *Of Unsucceeding Experiments*, 1661

Introduction

Medieval alchemy was and is famous for its dominant ambition: a search for the Philosopher's Stone, which would enable those who possess it to change base metals into gold or to indefinitely extend earthly life. In consequence, alchemy has given rise to many legends, especially its association with astrology and its practitioners' use of ciphers and cryptograms to record recipes and experiments, which have associated it with the occult and magic. Recent scholarship has rehabilitated alchemy from these false contexts and firmly established its contribution to various areas of scientific development. The alchemists' main preoccupation, the auric pursuit, resulted in a number of by-products useful to many artisanal occupations of the medieval and early Renaissance periods. For the fine arts, these were mainly pigments, but in medicine various herbal tinctures, creams and soaps were applicable, in metallurgical processes alchemical alloys were used, and the cloth industry benefited from compounded dyes, to list just a few. Inasmuch as artisanal and art-related instructions and recipes were often included in alchemical texts

1. Conrad Gessner, *Alchymia* (illustration from: *The Practice of the New and Old Phisicke*, 1599), courtesy of National Library of Medicine, Bethesda, USA
Conrad Gessner, Alchymia (ilustracija iz: The Practice of the New and Old Phisicke, 1599.), National Library of Medicine, Bethesda, SAD

and formulae, scholars have extended their study of alchemy to these seemingly unrelated documentary sources. The result has been the liberation of alchemy from its status as an esoteric pseudo-science to an acknowledged pre-scientific discipline. This has also prompted many researchers to adopt a more appropriate name: *chymia* and *chymistry* in lieu of the less reputable *alchemy*, burdened with its occult and magical associations.[1] In this field, two leading scholars, Lawrence M. Principe and William R. Newman, have been the inspiration for this study, and its fact-finding endeavor is greatly indebted to their innovative and creative investigation.

Although some critics tried to portray chrysopoeia (i.e. gold-making) *as operating in a non-natural manner that involved demonic agency and trickery, and was therefore something to be avoided, virtually all its advocates insisted on purely natural explanations.* Lawrence Principe, *The secrets of Alchemy*, 2012.

Alchemy has appealed throughout the centuries to those lured by promises of power and wealth while pursuing various experiments, but also to those merely interested in deciphering its many secrets. Alchemy's presence was felt practically in all areas of humanistic pursuits, and the term became a part of mythology, literature, poetry, fine art, psychology and psychiatry. The recent renewed interest is attested to by the popularity of such fiction as Marguerite Yourcenar's *L'oeuvre noir* (1968), Rowling's *Harry Potter* (1997–) and Coelho's *The Alchemist* (1988), translated into more than 80 languages. They follow a long line of writers whose characters or plot-structures follow the alchemists' ambition: the search for worldly riches, power, or the spirituality to be explored within ourselves.[2]

By contrast, alchemy has a new role in the history of science as a trailblazer for this early modern discipline, though with some exceptions.[3] (**Figure 1**)

The two main areas of alchemy's contributions are indisputably the invention of important laboratory equipment and the formulating of various processes which led to the discovery of useful compounds enabling or facilitating future scientific breakthroughs. It should also be pointed out that, historically, alchemists were recruited from all walks of life: physicians (Arnold of Villanova, Paracelsus), noblemen (king and emperor Rudolph II), scientists (Isaac Newton, Robert Boyle), tradespeople (silversmiths, dyers, brewers, bakers, cloth makers etc.), and religious personages: one pope (John XXII[4]) and a number of monks (Albertus Magnus, Bonaventura d'Iseo, Thomas Aquinas), along with many anonymous experimenters mostly dispersed in monasteries throughout Europe.[5]

The re-evaluation of alchemy was helped by the final acknowledging that the most creative minds of the Scientific Revolution, Isaac Newton (1643–1727) and Robert Boyle (1627–1691), if not full practitioners of alchemy, were definitely acquainted with it. This was revealed posthumously when their working papers became public.[6] Boyle knew of the dictum of Democritus (c. 460–370 BCE): *We think there is color, we think there is sweet, we think there is bitter, but in reality there are atoms and a void.*[7] Democritus had postulated that all matter is made of atoms (*átomo*) moving in empty space (κενός) following universal laws, their interaction resulting in material bodies. In Greek atomist theory, knowledge derived from the senses is misleading; only through intelligence can truth and understanding be achieved. Influenced by Democritus, Boyle developed his own theory that matter is made of tiny particles called corpuscles (*The Skeptical Chemist*, 1661).[8] Alchemists embraced to some extent the corpuscle theory in their belief that all matter has the same origin (*prima materia*) and a similar structure and thus has within itself the potential aptitude to transmute, i.e. to change from one form into another.[9]

So the question can be posed: why did alchemy's positive accomplishments not outweigh the negative perceptions of alchemists' endeavors?

In part, the answer is in the alchemists' defense of secrecy by assigning symbolic images and names borrowed from various spiritual areas to their materials, methods, and discoveries. This practice made it difficult to understand – and even to decipher – such entries in the numerous manuscripts that have survived since antiquity and

2. Peter Brueghel the Elder, *De Alchemist*, courtesy: British Museum, London
Pieter Brueghel stariji, Alkemičar, British Museum, London

the early Middle Ages (either in their original form or as transcripts/copies). Often the simplest formula presents itself as a magic spell or ritual.[10] In addition, alchemy was an eclectic practice with commonly-used techniques but no standardized methods or common language which would have facilitated the exchange of ideas, with the result that its texts often seem esoteric and thus incomprehensible.[11]

Painting and Alchemy

While pigments are essential to painting, no less essential is the relationship between fine art and alchemy. How are artists and alchemists comparable and their practices allied in any way? In part, the answer is in the texts of the medieval and early Renaissance treatises which explicitly linked the two: the copyists or compilers of the texts saw no special divergence among artistic and alchemical subjects, in that respect quite unlike modern historians, who like to split up the professions.

At the onset it seems that there is hardly any relationship between these "arts," but the pairing of a painter with an alchemist can be more natural than it would seem at first.[12] An alchemist and a fine-art master prompt numerous tales of professional near-insanity, they both strive to transmute something ordinary into extraordinary, and both deal with the transcendental qualities of matter. Like the world of alchemy, the world of fine art is often more seemingly real and more perfect than the materials it uses and the very nature it depicts or transforms.[13] Both seem to unlock the secrets of creation and creativity, and the mystiques of alchemy and fine art are still with us on many cultural levels. The comprehensive and somewhat radical exhibition at the *Museum Kunstpalast* in Düsseldorf (2014) synthesized the fascination that artists and alchemists share with the mystery of transformation, in which both see themselves as active participants.[14]

For alchemists/*chymists* before the Enlightenment, at a time when scientific methodology was slow, arduous and devoid of provable mathematical models and formulae and even a mutual language, explaining experimental processes and results relied perforce on vague suppositions and speculations, metaphors and allegories to convey the transformation of matter. This raised a material activity to the level of a spiritual and almost poetic endeavor, very alluring to visual artists who themselves sometimes became practicing alchemists or at least acolytes, both "arts" being well documented in their work.[15]

The representation of alchemical tasks in works of art was prompted, of course, by the changing social reputation (often negative) of alchemists themselves. However, even within the artistic representations, there is a distinc-

3. Flemish painter, *Theophrastus Bombastus von Hohenheim – Paracelsus*, 17th century (after Quentin Matsys), Louvre, Paris
Flamanski slikar, Theophrastus Bombastus von Hohenheim – Paracelsus, 17. stoljeće (kopija prema Quentinu Matsysu), Louvre, Pariz

tion between the illustration of work in the *alchemical laboratory* and artwork inspired by the *philosophy of alchemy*. Alchemists in their laboratories could be portrayed by artists as mystics, sometimes endowed with supernatural powers. Their dimly lit places of work, strewn with strange vessels, roaring fires and dense smoke, added to the idea of otherworldliness. Concurrently, Flemish and Dutch genre paintings of the 17th century could treat alchemists as imposters, objects of satire and symbols of human folly. David Teniers the Younger (1610–1690) often painted such scenes, but he and his followers were responding to the negative reputation that alchemists had in the general social norms of northern Europe and elsewhere. Alchemists were viewed as mysterious hermetics performing strange illogical actions, employing equally strange ingredients and utensils and jotting down unintelligible scripts accompanied by even more bizarre illustrations.[16] These images very likely inspired the idea of the mad scientist who conducts scientific experiments while suffering at the same time from both psychological and moral insanity, a theme amply exploited in literature, fine art and, later, film. The search for gold was interpreted as a selfish quest for personal gain, and the frugal, entrepreneurial Dutch considered alchemists to be fools who squandered their money on trivial and futile matters and who are eventually reduced to beggary.[17]

Pieter Brueghel (1525/30–1569), around 1558, satirically depicts an alchemist's workshop. Through the window, the alchemist's family is shown entering the poor house, brought by unsuccessful experiments which have squandered their livelihood. (**Figure 2**)

The fraudulent gold maker or, as Tara Nummedal calls him, *betrüger* certainly contributed to the delusionary endeavor of transmuting lead into gold.[18] The perils of alchemy are best illustrated by a short poem added by German printer Engeloff, editor of the *Rechter Gebraucht d'Alchimei* (1534), to a laboratory manual or *Kunstbüchlein* (Skills Booklet) which he purged of all obscure alchemical recipes, retaining only those of a useful and practical nature.[19] Like those before him, he too was critical of the profession.

Eight things follow alchemy:
Smoke, ash, many words and infidelity,
Deep sighing and toilsome work,
Undue poverty and indigence.
If from all this you want to be free
Watch out for Alchemy.[20]

However, there is a positive image of alchemy and alchemists in artistic representation which can best be illustrated with a specific example. The Swiss physician and alchemist Paracelsus (Theophrastus Bombastus von Hohenheim, 1493–1541) had been supposedly portrayed by, among many others the Flemish painter Quentin Matsys (1466–1530) in a painting, now lost, that had a van Eyckian *Léal souvenir* format to glorify the sitter. More than a century later, Rubens painted a portrait of Paracelsus, apparently based on that of Quentin Matsys, at a time when Paracelsus' reputation – and that of alchemy – had ameliorated. (**Figure 3**)

Indeed, Paracelsus had distinguished himself by practicing alchemy in order to improve man's existence rather than to acquire personal wealth, as he did value spiritual activities over material ones.[21] Paracelsus viewed the alchemist and the artisan as one and the same; a baker is an alchemist when he makes bread (bread dough gains volume through fermentation and itself becomes a fermentation agent), the weaver is an alchemist when he makes a cloth, and so on: in other words, alchemists were those who were able to separate the useless from the useful, who transmute an imperfect matter to create a perfect one.[22] In Catholic regions of Europe, there had been less criticism of alchemy because, in the late medieval period, there had been an attempt to incorporate theological concepts into the alchemists' philosophy. The link with Christian theology may have modified the suspicion in which alchemy was generally held, so Rubens' sympa-

4. Theodoor Galle, *Nova reperta*, plate 7, *Distillation* (engraving after Jan van der Straet), 1580/90, courtesy: National Gallery of Art, Washington
Theodoor Galle, Nova reperta, ploča 7, Destilacija (bakrorez prema Janu van der Straetu), 1580./90, National Gallery of Art, Washington

thetic portrait of Paracelsus in the early 17th century was understandable. However, it was late: critical and dismissive thoughts about alchemy ultimately prevailed, and by the 18th century, alchemists had been banished from the learned institutions of Europe, and alchemy lost its designation as a science.

Laboratory, alchemical implements and twelve vital processes

All the processes of art-making and alchemy necessarily occurred in a specific area, a workshop and a laboratory, although these two spaces now conjure very different images. For the term *laboratory*, its origin is conjectural, as is its date, in designating a distinctive place different from a workshop.[23] The Latin *laboratorium* is most likely derived from *laborare*, meaning *to work*. The term was not used for monastic workshops for the copying of manuscripts, these were called either *scriptorium* or *officina*, but by the 16th century both terms *laboratorium* and *officina* for general workspaces were utilized.[24] Early pharmacists, metal refiners, alchemists and possibly even some trades had at least a room or a designated space for the practice of their craft. Labavius (1555–1616), a German physician and alchemist, seems to have been the first to devise a comprehensive plan for a modern laboratory. His *Chemical House* presented a new approach envisaging an airy space, less smoky and acrid, with a detailed outline of where to place various furnaces and apparatus.[25] It was a laboratory which at the same time was a workshop and a place for an alchemist to live. Similarly conceived quarters already existed in the Uffizi in Florence by 1586: artists, artisans and alchemists collaborated by sharing living quarters and equipment as well as theoretical and technical knowledge.[26] (**Figure 4**)

A laboratory was also described and depicted by Solomon Trismosin (*Splendor Solis* 1532–1535):

The laboratory was in a large mansion called Ponteleone six miles away from Venice. I never saw such laboratory work in all kinds of particular processes and medicine as in that place.... Each workman had his own private room and there was a special cook for a whole staff of laboratory assistants.[27] (**Figure 5**)

Alchemists were not necessarily seen as heretics, as they did not engage in preaching any doctrine counter to the

5. Jan van der Straet, *An Alchemist's Laboratory*, 1570, courtesy of Palazzo Vecchio, Florence
Jan van der Straet, Alkemičarev laboratorij, 1570., Palazzo Vecchio, Firenca

Roman Church. However, it was not unreasonable to correlate certain actions which might seem self-indulgent and in opposition to the Church's teachings. In the 12th-century treatise *On Divers Arts* by a certain Theophilus (Prologue to Book III), he attempts to justify and reconcile man's fascination with gold and other precious objects with obligatory humbleness.[28] He refers to King David's desire to *embellish the material house of the Lord* (*ornatum materialis domus Dei*), or to Moses', whom God instructed not only to build the tabernacle, but also to select masters who would be able to "devise and execute work in gold, and in silver and in brass... in precious stones" (*in omni doctrina implesse ad excogitandumet faciendum opus in auro et argento*), thus justifying the recipes that follow, which instruct on how to fashion objects from silver and gold, embellishing them with precious stones.

However, pursuing certain experiments involved rituals, invocations of spirits and activities considered God's dominion. The Church could not tolerate what it deemed magic, and therefore also certain alchemical activities. In order to protect their work and indeed themselves, alchemists tried to reconcile alchemy with religious concepts.[29] This was extended even to the names of alchemical vessels and processes. For example, the crucible (Latin *crucibulum*), a vessel that can withstand very high heat, derives its name from the Latin root *cruciare*, to crucify, so the term can be translated as a "place of torment" and used with that reference.[30] Likewise, various materials in a laboratory are subjected to harsh manipulation such as grinding, hammering, melting, scraping etc., in keeping with the notion that matter needs to be destroyed before ascending into a higher realm.[31]

Our knowledge of medieval, Renaissance and later alchemical laboratories – or, to put it frankly, the clichés and prejudices about them and their denizens – comes from the hundreds of drawings and paintings of their interior spaces and equipment.[32] Most often the alchemist's laboratory was illustrated as a dilapidated and ramshackle locale with one or more furnaces or *athanors*,[33] spewing smoke and pungent, caustic smells. Various scientific equipment (often broken) is strewn about, and the atmosphere of "magic" was augmented by taxidermically-prepared animals, mostly lizards, crows or owls, suspended from the rafters. The alchemist, generally in torn, shabby clothes and with a pointy hat, is portrayed as an exotic or foolish type working alone or with assistants, equally scruffy. Cornelis Bega depicted a bearded alchemist in tattered clothes surrounded by implements of his métier. Bega's thematic repertoire included representations of quack scientists, especially alchemists, a subject he depicted at least four times. The version in the J. Paul Getty Museum in Los Angeles depicts a cluttered, shabby interior in which a bearded alchemist in tattered clothing is surrounded by the detritus of his profession: books and papers, cryptic substances, bottles, strangely shaped jars, and chipped earthenware abound.[34] (**Figure 6**)

The large bellows in the foreground of Bega's image are typical of the genre and contributed to the derogatory name *puffers* or *souffleurs*, by which alchemists were known.[35]

Books, as symbols of erudition, are depicted: their presence is also typical without being in any way documentary evidence of the contents of such venues.[36] While these images are standardized elements which may – or may not – show laboratory interiors and set-ups, the basic arrangement and the type of implements for spaces of alchemical work had already been listed by the Arab alchemist Muhammed ibn Zakarya al-Razi (854–925) and illustrated in a great number of alchemical manuscripts.[37] The major accessories consisted of a fireplace/furnace, bellows which were instrumental in raising the oven's temperature, and distillation apparatus: alembic, cucurbit and pelican, and crucible for calcinations. There were also various beakers and flasks, glazed earthenware pots and a number of smaller utensils such as crystallizing dishes, funnels, filtering vessels and mortars. Regarding chemical processes, Razi mentions distillation, calcination, solution, evaporation, crystallization, sublimation, filtration, amalgamation and ceration.[38] These basic pro-

6. Cornelis Bega, *Alchemist*, 1663, Courtesy: J. Paul Getty Museum, Los Angeles. Images are in public domain, Getty Research Institute
Cornelis Bega, Alkemičar, 1663., J. Paul Getty Museum, Los Angeles. Slike su u javnoj domeni, Getty Research Institute

cesses hardly changed over centuries, though a few more were added over time.

Alchemy – its major doctrine and its twelve vital processes

The major doctrine of alchemy was termed *Opus magnum*, its component parts being *Materia prima* (the material elements) and the Philosopher's Stone. *Opus magnum*, or the Great Work, was needed in order to generate the Philosopher's Stone through various materials. Three important schools (among others) developed: one emphasizing vitriol (usually iron sulfate), another nitre (saltpeter), and yet another mercury as the prime ingredient for the Great Work.[39] A modern analogue to the Stone would be a catalyst: a substance that influences a chemical reaction without itself undergoing any permanent chemical change. The Stone thus came to be known as the true *Universal Quintessence*, *Universal Medicine*, *Panacea* or *Fountain of Youth*. Philalethes sums it up as: *the Balsam of Nature, expelling all diseases, and cutting them off as it were with one Hook, all that are accidental to the Humane frail Body, which is wonderful.*[40] For Basil Valentine (1394–1450) it is even more intangible: *It is called a Stone and yet is no Stone / And in that Stone Dame Nature works alone.*[41]

Alchemists eventually developed twelve vital processes to transmute lower-level matter into a higher or nobler state. Some or all were used in alchemical experimentation: calcination/purification, solution/dissolution, separation, conjunction/coagulation, putrefaction, congelation, cibation, sublimation, fermentation, exaltation, multiplication and projection. Purification through calcination refers to decomposing the "raw" matter; solution or dissolution to melting or breaking up; coagulation or conjunction refers to "simmering" or of "matter" coming together; sublimation, and sometimes fermentation, refer to the rebirth of a new substance. Cibation refers to adding fresh substance to provide a means of evaporation.[42] Sublimation is a phase of transition, but in the alchemical sense it refers to an exchange of "bodies" and "spirits," such as separation of spirits in wine and beer:

This Transmutation of Wine into Vinegar is a wonderful Thing; because somewhat is produced from Wine, which was not before in its vegetable Essence. In which it is also to be noted, that in distillation of Wine the Spirit first comes forth; but (on the contrary) in distilling Vinegar the Phlegm first comes, afterward the Spirit, as I have showed above in its own place, where I also made mention of this Example.[43]

In some alchemical texts, such as the one by George Ripley (1415–1490), this takes on a double, even theological, meaning, referring to the spiritualization of the body and the corporalization of the spirit.[44] Exaltation signifies the refinement or subtilization of bodies or of their qualities and virtues. Ripley's *Tenth Gate* mentions: *From time the parties be disposed, / Which must be crucified and examined, / And then bury together both man and wife, / To be after revived by the spirit of life.*[45] The image of man and wife often refers to King and Queen, i.e. gold and mercury.[46] Multiplication refers to the Philosopher's Stone, whose potency is increased at the end of *Magnum opus*. Ripley refers to it in reference to medicine, but generally it was mostly concerned with the production of gold and silver.[47] Finally, *projection*, the very last part of a complex process system, was the ultimate goal of alchemy. Through projection, a lesser substance (usually lead) would achieve a higher form (gold).[48] Double-bottomed crucibles or hollow mixing sticks were used to conceal hidden gold during fraudulent projection demonstrations.[49]

Cennini's claim that some pigments were "made by alchemy" had a fore-runner in Theophilus' manuscript *On Diverse Arts*, especially his recipe entitled *Spanish gold*. Both writers will be discussed in detail further on. Theophilus' treatise had wide distribution and lasted a long time: no less than twenty-five manuscripts containing varying portions of the text survive in libraries in Germany, France, England, and Italy.[50] *On Divers Arts* is repeatedly cited as representing the experience of a humble craftsman working for the glory of God and as such is used extensively for the study of medieval art.[51] In addition, the scholarly Latin of the text, and especially its theoretical prologues to practical operations, identify Theophilus as much more than a 'humble' craftsman.

Both prologues and recipes/instructions represent a unique format among 12th-century instructional manuscripts. Central to the study of Theophilus's treatise, and indeed the study of other alchemical texts, is the question of whether they are primarily philosophical texts or practical ones.[52] In view of this inquiry, the *Schedula* and its different recensions indicate that Theophilus covered both topics belonging to different genres of literature: conceptual and empirical.[53] In a way, the format is a precedent to the postulation by Roger Bacon (c. 1214–1294) in his *Opus majus* (c. 1267) of two *alkimie*: *alkimia speculativa* or theoretical alchemy, and *alkimia operativa et practica* or alchemy's heuristic quest.[54] The former deals with the generation of things, whereas the latter instructs on the manufacture of precious metals, pigments and other items of *chymical* technology. The prologues furthermore demonstrate that the author was well acquainted with the attempts of medieval alchemists to reconcile their activities with the current religious concepts. The Prologue to Book III, containing the recipe for making *Spanish Gold*, follows the same stratagem.[55] The recipe's ingredients have puzzled numerous translators and necessitate a more detailed analysis further on in this paper.

Transmutation, a threat to the economy

Generating gold was the alchemists' most notorious claim to fame, but also the most dangerous aspect of their work. Historically, gold and silver were the basis of a sovereign state's economic stability, even though, in practice, monetary systems had recourse to base metals rather than silver or gold in pure form. Debased coins were dipped into a proper tincture, well known to alchemists, to make them look like the precious metal. Most recipes claim that, with appropriate manipulation, the substitute would seem to the observer or a user just like "real gold" (*ut littere videantur de auro)*.[56] Rulers and ecclesiastical authorities recognized the danger presented by the alchemists' knowledge to produce fake gold coins by simply tinting or patinating bronze or any other metal. The Roman emperor Diocletian, concerned with this deception at the time of a rebellion in Egypt in 297–298 CE, forbade the practice of alchemy and may have ordered its practitioners' books to be burned.[57] The custom of illegally introducing alchemically manipulated coins went hand in hand with other means of debasement to increase the supply of specie in medieval and later periods.[58] Uncontrolled multiplication of noble metals was a concern for most sovereigns: in 1404 Henry IV (1367–1413) issued a statute against it, and while alchemy was permitted during the reign of Henry VI (1421–1471) and Henry VII (1457–1509), the statutes against alchemy and multiplication remained in force, and in 1457 a commission was charged with arresting anyone practicing alchemy without the royal license.[59] Laws against alchemical multiplication were repealed only in 1689.

Church authorities acted earlier and were less equivocal: Pope John XXII issued a decree (*De Crimine Falsi Titulus VI. I Joannis XXII*. c. 1317) condemning alchemists because *they promise that which they do not produce*.[60] Although the pope's primary target were those alchemists counterfeiting currency, it also condemned alchemists claims of having power over nature. In addition to fake coins, edicts against alchemy were argued on the religious ground that transmuting matter should be reserved for God alone, a view prudently upheld by the alchemist known as pseudo-Geber (13th century), who forbade his disciples to meddle with sophisticated operations because *our art is reserved in the divine will of God*.[61] The hostile civil and ecclesiastical environments prompted *bona fide* alchemists to put themselves in the service of wealthy patrons in order to expose fraudulent colleagues while at the same time securing lucrative employment, or to seek protection within monastery walls.[62]

Alchemy and monastic environments

The burning of their books and their targeting by established authority may have made some practicing alchemists to go into hiding, but there was one venue in which they could find safety and support, namely monastic institutions. Many belonged to religious orders despite the general disfavor of the Church.[63] Dodwell suggests that Theophilus was not just a practicing craftsman but also a member of the Benedictine Order.[64] Vincent of Beauvais (13th century), a sub-prior of the Dominican Order and author of a famous encyclopedia (the *Speculum Maius*) was familiar with Arabic sources and accepted the transmutation of materials as a viable possibility.[65] Two contemporaries of Vincent, the Dominicans Albertus Magnus (1205–1280, a provincial of the Order and later bishop) and Thomas Aquinas (1225–1274), were likewise alchemists. Thomas Aquinas was aware of both trickery and fraud in alchemy, well aware that there were substances that can make metals white (*silvery*) and others, like sulfur and arsenic, can make them look like gold. *If you project upon copper some white arsenic sublimate, you will find copper become white; if you add a part of pure silver you will transform all the copper into silver*.[66] He was convinced that making gold or silver was a viable possibility: *to sell gold and silver made by the alchemists, if it has no nature of true gold and silver, is fraudulent. If, however, it is true gold or silver, the transaction is lawful*.

There may have been various reasons for monastic environments to have become venues for alchemical pursuits. Income derived from alchemy could have been used to help the poor or pay for the upkeep of the religious community.[67] Equally attractive might have been the suggestion by Roger Bacon, himself a Franciscan monk, that

7. *Hermes Trismegistus*, illustration from: MICHAEL MAIER, *Symbola Aureae Mensae*, 1617 (Image from reprint by D. Stolcius von Stolcenbeerg, *Viridarium chymicum*, 1624, source: Wikimedia) *Hermes Trismegistus, ilustracija iz:* MICHAEL MAIER, *Symbola Aureae Mensae, 1617. (preslika iz reprinta D. Stolciusa von Stolcenbeerga, Viridarium chymicum, 1624., izvor: Wikimedia)*

the true pursuers of alchemy shall achieve wisdom and salvation.[68] Monasteries were ideal places to practice in relative peace and security, and their members were better educated than the general populace and had the time and support to undertake the rigorous complex experiments that alchemy required.

Alchemy sometimes aligned with the 12th-century rediscovery and revival of classical philosophy and science in the Latin West when many of the ancient texts were translated from Greek or Arabic into Latin. Monks fluent in these languages were employed as translators,[69] and some, like Alfred of Sareschal, appended alchemical texts to the philosophical ones, thus combining classical texts with the lore of alchemy.[70] To his translation of Aristotle's *Meteorology*, Alfred attached writings by Ibn Sina (better known as Avicenna, 980–1037) on metals which involved alchemical manipulation.[71] In addition, the Christianization of Aristotle's texts merged ancient philosophy with Holy Scripture and Church doctrine, with the result that Aristotle's notion that all matter is a combination of four elements – earth, air, fire, water – also became an important principle of alchemical theory and practice.[72]

Cover names – *Decknamen*

The aforementioned recipe of Theophilus for *Spanish Gold* is also a good example of alchemists using the so-called *Decknamen* or "cover names" to conceal key ingredients of their recipes.[73] The Sun and the Moon were common *Decknamen* code-words for gold and silver. In fact, all seven metals known in the medieval world had an astrological pseudonym simply because the number of known metals equaled the number of known "movable" heavenly bodies.[74] The relationship between metals and planets is a reflection of a belief supposedly initiated in the writings of Hermes Trismegistus, which claimed that phenomena in the heavens had equal counterparts on Earth and vice-versa. The credo "as above so below" is recorded on the *Emerald tablet* attributed to Hermes and is often depicted graphically or referred to textually.[75] (**Figure 7**) It was also very common to call many different substances by the same name and the same substance by a number of different names for the same purpose, resulting in a metaphorical coded language known only to the author and a few initiated disciples.[76]

In general, alchemists strived to protect their findings by using allegorical and symbolical imagery: metals, planets etc. are compared to biblical personages or events, but also pagan deities, or mythological fables; symbols like the egg, dragon (basilisk in the *Spanish Gold* recipe) and phoenix are depicted, as are references to marriage, death or resurrection.[77] Not all were in accordance with this practice; Paracelsus in some documents actually admonishes the use of *Decknamen*: *... they have gone so far as to invent obscure names... Who shall quickly interpret the deformed child to be the she-bear, and the gum of the vine of Dionysius to be the gum of the ivy*.[78] On the other hand Jabir ibn Hayyan (died 815) was instructed by his master (Ja'far as-Sadiq) *...reveal the knowledge as you desire, but such that none have access to it but those who are truly worthy of it.*[79] Some actually feared that the power to create gold or to alter matter could too easily be used for evil purposes if the knowledge fell into the wrong hands.[80] In addition to code words, ordinary substances were described in fantastical manner. The best known example is the often mentioned origin of *Dragon's blood*, actually a red colored resin obtained from the *Dracaena Drago* plant. According to both Pliny and Ibn Sina the color was the result of spilled blood as an outcome of a mortal battle between an elephant and a dragon.[81]

The alchemy of paint, Alchemical processes and stages

Let us return to the relationship of alchemy and "paint". Colored pigments used in various techniques and fixed in place by diverse binders or mediums are intrinsically connected with the history of art from the earliest cave paintings to our day. Colorants enhance utilitarian objects and works of art with equal versatility, and their many uses in different aspects of human endeavor have been the object of study by several scholars, notably John Gage (symbolic use of color), Philip Ball (chemistry and technology), Victoria Finlay (stories about origin) and Spike Bucklow (mystical significance of color).[82] Both Philip Ball and (especially) Spike Bucklow have emphasized the alchemists' involvement in substantially enriching artists' options in the way of colors, clarifying alchemy's contributions to the range of artistic possibilities.

Disregarding the importance of alchemy is mostly due to the nomenclature: when discussing the origin and composition of pigments, the term *chemistry* was and still is preferred to *alchemy*, regardless of the date when a specific color was synthesized or became part of the artists' palette. The term *chemistry* is habitually used for periods when that branch of natural science was actually known by its other name. Therefore any colorant, or for that matter any other substance discovered prior to the genesis of modern chemistry, should be identified, as Cennini says, *as obtained by alchemy*.[83] The chemical process by which some of the oldest pigments, such as lead white, *minium*, verdigris or vermilion, were obtained is discussed in countless works of ancient and modern literature and, more recently and more comprehensively, in the *Pigment Compendium*.[84]

Cennini, in his *Il libro dell' arte*, has already given us some evidence of alchemical practice: *Rosso è un colore che si chiama cinabro: e questo colore si fa per archimia, lavorato per lambicco* (Chapter XL).[85] He unequivocally mentions several pigments that were made by alchemy. He does not give detailed recipes: *I will not tell you how it is made*, but advises the artist to purchase them *from friars* or from the *druggist*. Cennini is not always consistent; he gives a specific description on how to obtain ultramarine from lapis lazuli, or *purpurina*, but fails to mention that purpurina is obtained *by alchemy*.[86] The pigments red lac and *giallorino* are made artificially, whereas vermilion is made by alchemy. A distinction is made between pigments obtained with the help of alchemy and the "artificial" ones. Thompson suggests that for Cennini, any material produced by volcanic activity (*giallorino*) is not considered to be a product of the alchemist's laboratory.[87]

Alchemical processes and stages

For the Great Work or *Magnum opus*, the identifiers of key color-coded stages in the alchemical transmutations are black, red and white (from *nigredo* to *rubedo* to *albedo)*.[90] Not all three stages were necessarily always present. The link or interdependency between artists and alchemists as initially stated is well demonstrated in the manufacturing of some pigments to be briefly discussed; each step of the process can be described as truly alchemical.

In this context, lead white (and verdigris to some extent) is the prime example of a fully accomplished alchemical change. Even artists, not just the adepts, knew that black lead can be converted into ceruse and, if calcined into *minium*; calcination being a quintessential alchemical process. The synthesis of lead white satisfied and validated the legitimate question: is transmutation possible? If a black metal like lead can be changed into the most brilliant white pigment, why couldn't any base metal be changed into gold or silver? (**Figure 8**)

The production of ceruse was a two-fold process: first the shiny, but dark, ore *galena* (Lead (II) sulfide) was turned into the now dark but dull metal, and then this metal into a most brilliant white ($2PbCO_3 \cdot Pb(OH)_2$) and, if calcined, into red (Pb_3O_4 or $2\ PbO \cdot PbO_2$).[91] The first part of the lead-white production was labor-intensive, while the second part was practically self-fulfilling.[92] The recipes often note the length of time necessary for the metal plates to oxidize and be covered with white pigment. Forty days is usually suggested. The number becomes significant in reconciling alchemy with biblical events: the number 40 is habitually quoted in the Bible in contexts dealing with

Cennini's *Il libro dell' Arte*: artificial pigments and those "made by alchemy"		
PIGMENT	Chapters	ALCHEMY or ARTIFICIAL*
Vermilion (*cinabro*)	XL	*si fa per archimia, lavorato per lambicco*
red lead (*minio*)	XLI	*artificato per archimia*
red lac	XLIIII	*è colore artifiziato, di gomma colore sanguineo*
*giallorino***	XLVI	*artifiziato ma non di archimia*
orpiment	XLVII	*è artificato, è fatto d'archimia*
arzica (*Reseda luteola*)	L	*colore archimiato*
malachite (*verde azzuro*)	LVI	*si fa artifitialmente*
lead white	LVIIII	*colore archimiato di piombo*
verderame (verdigris**)	LVI	*è artificato con archimia*

*The distinction between "natural" and "artificial" colors is an ancient one.[88]

**Verdigris, synthesized in the same way as lead white, is not mentioned as obtained by alchemy in Thompson but is indicated as such by Milanesi (No. LVI).[89]

8. Galena, lead, ceruse (photo by S. Bogović Zeskoski, 2017)
Galenit, olovo, ceruzit (snimila S. Bogović Zeskoski, 2017.)

judgment, "probation" or "trial" thus connecting the physical world with the spiritual.[93]

Cennini's *giallorino* presents a different challenge. He was the first who gave a pale yellow color the name *giallorino*; however, there is much confusion in identifying its chemical composition. Giallorino, Cennini points out, is "artificial, but not made by alchemy" (*giallorino sia colore arteficato ma non d'archimia*). He says that it can be found where great burnings of mountains occur (*arsure di montagne*).[94] Merrifield took this as a reference to a "volcanic product"[95] which, in turn, erroneously associated the color with activities of Mt. Vesuvius and the city of Naples, suggesting that *giallorino* is Naples yellow ($Pb_2Sb_2O_7$). The problem with this identification is the presence of antimony, which had not been identified on any paintings executed during Cennini's time.[96] The literature speculating about the true composition of *giallorino* is abundant. A recent monograph devoted to the problematic pigment has over 300 pages, copious notes and extensive bibliography.[97] Numerous earlier analyses of yellow pigments further contributed to the confusion. Most yellows were assumed to be lead oxides and additional scrutiny for the possible presence of tin or antimony was seldom conducted.[98] Thompson suggests that *giallorino* is neither massicot nor a type of frit (i.e. lead-tin-quartz mixture), but some pigment not yet identified, of a corresponding hue.[99] If we assume that *giallorino* could be lead tin yellow type II ($PbSnO_3$), whose presence has been detected in paintings dating from the 14th to the 16th century,[100] then Cennini must have had other reasons to point out its non-alchemical origin. Most likely because it was found in nature rather than conceived in a laboratory. However, manufactured lead tin yellow requires fusion of lead and tin at high temperatures (about 800 °C). The two almost black materials transmute, through calcination and dissolution, into a higher matter light in color, reaching one of the *Magnum opus* levels, the *citrinitas*. Lead tin yellow was also used in lieu of metal leaf or powder when real gold was not available or was too costly;[101] therefore as a gold look-alike, fulfills the alchemists' transmutation of "ordinary" metal into a noble metal, albeit ersatz. It should briefly be pointed out that massicot and litharge, although often identified as *giallorino*, are two different pigments.[102] Massicot is a yellowish unfused monoxide of lead, and only 300 °C is required for its preparation, while litharge is obtained directly from the molten metallic lead at a temperature of 1200 °C and has a reddish tinge.

Whenever mercury and sulfur were required in a recipe, alchemy must have been the originator, since those two elements are the main protagonists in most transmutations. To synthesize vermilion, the costliest pigment after lapis lazuli, and alchemist's dream pigment par excellence, both sulfur and mercury are present. Furthermore, the union of alchemical Mercury and Sulphur in perfect proportions produces the Philosopher's Stone, often referred to as the Red King, depicted robed in vermilion.

Vermilion recipes can be very explicit or described in less understandable allegorical terms, comprehensible to the initiate but not to the non-professional.[103] Theophrastus described the methodology in *De Lapidibus* (315 BCE),[104] and Jabir ibn Hayyan enlarged upon Theophrastus, introducing several alchemical stages.[105] Translations of Jabir's writings into Latin disseminated the knowledge to the West.[106]

The dry process[107] in manufacturing vermilion embraces the quintessential alchemical operations: separation, purification and re-integration, following the dictum *solve et coagula*. Vermilion is a good example of a by-product that has the same, if not greater value as the original material sought through the refining process. Vermilion is obtained from cinnabar ore (HgS), which is also a main source of mercury. In the initial stage of the process, mercury and sulfur mix together into black mercury sulfide (*nigredo*), heated during the second and third stages, sublimation and condensation (*solve et coagula*). And finally, the vaporized and recondensed vermilion is deposited on the inner perimeter of a vessel which is then broken to collect the pigment (*rubedo*). The combination of two of alchemy's basic ingredients, a darkly metallic mercury and a bright

yellow sulfur, gives vermilion the designation of a transformative proto-Stone.[108]

Vermilion's notable variation in hue is caused by the size of the pigment's particles. Larger crystals produce a duller and less-orange hue; thus Cennini suggests: *if you were to grind it every day even for twenty years it would keep getting better and more perfect.*[109]

Cennini also suggests obtaining vermilion from friars (*pigliando amistà di frati*),[110] while Theophilus gives a detailed account of how to prepare it:

Take sulfur, break it up on a dry stone, and add to it two equal parts of mercury, weighed out on the scales. When you have mixed them carefully, put them into a glass jar. Cover it all over with clay, block up the mouth so that no fumes can escape, and put it near the fire to dry. Then bury it in blazing coals and as soon as it begins to get hot, you will hear a crashing inside, as the mercury unites with the blazing sulfur. When the noise stops, immediately remove the jar, open it, and take out the pigment.[111]

In addition to ordinances concerning the production of false coinage, similar restrictions were placed on vermilion, which was also worth its weight in gold. In Roman times, it was forbidden to break up or refine cinnabar ore where it was mined; instead, it had to be sent to Rome, under seal.[112] The sale price was fixed by law to keep it from becoming impossibly expensive, but its cost was still sufficiently high as to entice adulteration with the cheaper *minium*. Several manuscripts instruct artists on how to detect various contaminants.

Of blues, the Egyptian blue (*caeruleum*), considered to be the first synthetic pigment, qualifies as "obtained by alchemy". It is actually a "blue glass" made of silica, copper and alkali.[113] It is also considered to be a frit, regardless whether fine or coarse, because it is a product of solid-state reaction.[114] The characteristic color is due to the presence of copper and hues can range from light to darker blue. *Caput mortum* is another alchemical product originally referred to as a useless substance left after some processes (also from burning vitriol) and is often called *nigredo*. Bucklow considers the *caput mortum* of alchemical recipes as "brown" pigment, suggesting that some had been prepared artificially, although it is more often identified as "earth."[115]

Nomenclature

Inconsistency in the naming of materials has plagued the research of alchemical nomenclature in ancient manuscripts, and many medieval color terms are still contested.[116] Contemporary glossaries are not necessarily helpful. Alexander Neckam (1157–1217) identified colors used by miniaturists, but in a rather vague manner, adding to the confusion.[117] He (also Pliny) identifies minium as vermilion and *Phoenician* (*puniceus* or *fenicius*) as *vermeilles* or *rouge*, and as Gage rightly points out: *we should note that he and his glosators were happy to qualify "red" with a number of different terms.*[118] Cennini, for example, distinguishes between cinabrese and light cinabrese, the latter identified by Thompson as Pozzuoli red.[119] In other words, when consulting old manuscripts and ancient glossaries one must be aware of ambiguities and turn to more than one source for a proper and correct identification.[120]

The *Spanish Gold* of Theophilus

Still, textual aids in examining works of art can be of great assistance when approaching the conservation/restoration of works of art. I recall having a discussion with a colleague who was adamant that artificial gold (i.e. metal powders) could not be anything but a modern addition on a Baroque polychrome sculpture. Yet the recipes for such gold can be traced back to Egyptian papyri and are repeated in quite a few manuscripts.[121]

In view of the above statement let us examine the unusual recipe by Theophilus which he titled *Spanish Gold* (*aurum Hyspanicum*). From the name *Spanish gold* we may also assume that by that time a number of the Arabic recipes were already translated into Latin, i.e. earlier than the activities of the translating schools of Toledo and Paris.[122] The recipe appears in Book III, *The Art of the Metalworker*. By the initial sentence the *Spanish gold* recipe is distinct from all other instructions, which are practical and straightforward.[123] *There is also a gold named Spanish gold which is formed from red copper, basilisk powder, human blood and vinegar.* The recipe then mentions how the ashes of a mythical basilisk are come by. Basilisk's eggs are obtained by the copulation of two roosters twelve to fifteen years old. After the eggs are laid, the roosters are replaced with a toad to incubate the eggs. Shortly after hatching, male chicks grow serpent tails. The chicks are then put in a brazen vessel with a copper lid, nourished for six months and lastly burned into ashes. The ashes are then mixed with human blood from a red-headed man and tempered with sharp vinegar.

Then they (the heathens, i.e. the Arabs) *take very thin flat plates of the purest red copper and smear this composition on both sides of them and put them in the fire. When they are red hot they take them out and quench them in the same composition and wash them. They keep on doing this until the composition eats through the copper, which thereby acquires the weight and color of gold. This gold is suitable for all kinds of work.*[124]

The ingredients have perplexed the translators and researchers of the treatises: *...it is astounding that as practical*

a man as Theophilus should include the present fantastic chapter.[125] The simplest way to explain the strange recipe was to attribute it to the *garbled account of the making of brass* originally *written in the symbolic and lurid language of alchemy*.[126] Clarke dismisses it, and other rare and odd recipes, as *Gedankenexperiment*. In other words, they might have been added by a craftsman as a note to try it later, if by chance there might have been some merit to it, or added much later by a non-professional reader who made the notation without any intent to put it to the test.[127] Clarke also points out that reworking texts was very common, and transcribing them was often divorced from workshop practices, which results in technical inaccuracy.[128] Clarke, not with good reason, often rejects alchemy's secret language, searching for a rational explanation of it, even though he himself tested some dubious instructions such as *...always stirring it with dog's foot that has its hair and wool*. Experimentally, he found out that the fuzzy dog's paw is essential to combine two almost immiscible materials such as "liquid" mercury and powdered sulfur, the two main ingredients in making mosaic gold.[129] The most bizarre ingredient in the recipe of course are the ashes of the basilisk, a mythical creature seen as a combination of a rooster with a snake-like or lizard-like tail. As in heraldry lizards (also salamanders and sometimes basilisks) are mentioned in the alchemical literature quite often.[130] The 16th-century manuscript *Rechter Gebrauch der Alchimie* (The Proper Use of Alchemy), in addition to recipes for making pigments, has several on how to make gold. The recipe calls for lizards to be treated in a similar way as Theophilus's basilisk: the legend evidently persisted.[131] The manuscript is supposedly based upon an alchemical treatise by Petrus Kerzenmacher (the MS, though referenced, has not been found).[132] The process in most accounts is rather similar: lizards or basilisks are fed for some time and later burned. The recipe also calls for human blood, into which lizards are dunked immediately after being caught.

The significance of alchemical blood is manyfold: it refers to crucifixion and resurrection (*shedding of the blood of a pure being to wash away the sins of an impure one*). Likewise, in the final stage of purification of matter, or *rubedo*, blood symbolizes the precious red elixir or tincture (also associated with the Philosopher's Stone). Albertus Magnus, in *De animalibus*, wrote about the killing gaze of the basilisk, but he denied other legends, such as the rooster hatching the egg (*ego non puto esse verum*).[133] He gave as source Hermes Trismegistus, who introduced the need for the basilisk's ashes to convert silver into gold, although such claim does not appear in any known texts of Trismegistus'.[134]

Finally, references have been found in a Sicilian MS, possibly belonging to the Jabirian corpus, which are tentatively related to Theophilus' manuscript the *Schedula*.[135]

Bucklow has rightly argued that, if we ignore one recipe from Theophilus' treatises, why not all the others as well? In other words we should not really "pick and choose" what suits well our idea of a viable recipe.[136] Abufalah, an 11th-century Arabic alchemist from Sicily, also calls for basilisk's ashes to make gold.[137] In alchemical language the recipe ingredients can be identified as such: basilisk's ashes which are white or silver (*albedo*) represent mercury; the red-haired man (*rubedo*) refers to the necessary presence of fire and human blood stands for sulfur (*citrinitas*).[138] Blood was considered a powerful agent, necessary to cut gemstones, and Theophilus lists that recipe as well.[139]

Petrus Kartzenmacher, *Alchimia* (1538 XXIX verso), states that philosophers have hidden the fact that human blood is good for making silver and gold, and that all should know that menstrual blood or *sangue rubei collerici* is the best for the art of making gold and silver.[140]

In lieu of a conclusion

As mentioned in the introduction, ancient recipes with strange ingredients or instructions should not be dismissed as mistakes, additions of ignorant scribes or intentionally fraudulent scripts. Egyptian hieroglyphs remained arcane and enigmatic for centuries even though numerous attempts were made to decipher the hidden meaning of the pictographs. A similar approach should be adopted when dealing with obscure recipes until a right key for their interpretation is found. The key, most likely, will not be some kind of Rosetta stone, but an open and investigative approach embracing the philosophy and reasoning of the period in which the texts originated. Alchemy was never about what people *believed* in; it was what people *did*.[141] It was practiced independently in nearly every developed culture: alchemists worked in the Far East, India, North Africa and the Islamic world before reaching Europe. As demonstrated by Theophilus' treatise and the *Spanish Gold* recipe, the instructions can be deliberately cryptic, often with intricate notes and diagrams, or explained by Cennini, when he cared to do so, in easily reproducible details. Secrecy, as has been pointed out, was needed for various reasons, but recording experiments demonstrated a strong will to hand down newly obtained knowledge to future generations of adepti. Unusual recipes that stand out like *Spanish Gold* were possibly copied from even older sources, but their meaning is still understood. Alchemists had learned to manipulate nature and, even when monumentally wrong, they were the precursors to the story of science, as their "partial" success yielded valuable materials and processes. Their "scientific" attempts were initially intertwined with spirituality, which made it easy for later scientists to dismiss them as tricksters or madmen. The manufacturing of artists' pigments, the main focus of this paper, formed a negligible objective within the alchemists' opus, but it is

a verification of many successful and useful alchemical experiments.

Preserving and treating works of art requires a thorough knowledge of the materials they are composed of. Modern science has made this task vastly easier by making numerous analytical methods available to the profession. However, such investigation is done mostly by scientists who can rarely be sensitive towards the entire object, seeing it as a composite of many parts, not to say specimens. Recently, there has been a more holistic approach toward treating a work of art. In addition to utilizing what science can offer, sensitivity towards an object's structure and make-up is considered to be of equal importance. Information and proper interpretation of old treatises becomes a valuable tool in these efforts. Knowing "alchemical" language therefore becomes a necessity. As already mentioned, awareness that there were bronze powders instead of gold leaf present on artworks even during medieval times precludes the erroneous assumption that "those are just modern additions." With the new research-based scholarship, investigating alchemy's objective and intention, freed of its occult image, the task of deciphering the legacy of alchemists has been made feasible and so much easier. ■

Notes

1 On the argument for using the term *chymistry* see WILLIAM R. NEWMAN, LAWRENCE PRINCIPE, 1998, 3. Robert Boyle in the 17th century called himself a "skeptical chymist", not an alchemist.

2 For some alchemists the transmutation would occur only if one's soul was similarly transformed. DAN BURTON, DAVID GRANDY, 2004, 74–86.

3 GLYNIS L. COYNE, 2012; BRUCE T. MORAN, 2005, 1–7, 34–36, 69–70. For an opposing view see HERBERT BUTTERFIELD, 1951, 98. The prominent Cambridge professor, dismissed not only alchemists, but also historians who researched the topic as being *...tinctured with the same type of lunacy they set out to describe*. Butterfield's views were opposed by Vickers, who considered the simplistic generalizations to be *unworthy of a serious historian*, although Vickers did attack William Newman for being an "apologist" for alchemy. BRIAN VICKERS (ed.), 1984, 1–56.

4 However, in 1317 Joannis XXII issued a decree *De Crimine Falsi Titulus VI*, warning that those practicing alchemy must forfeit to the public treasury, for the benefit of the poor, the gold and silver they have manufactured. ROBERT HALLEUX, 1979, 124–126, text in Latin and French translation.

5 WILFRID THEISEN, 1995, 239–253.

6 SARAH DRY, 2014, 4, 106–107.

7 KATHLEEN FREEMAN, 1948, 92.

8 In turn, some consider that Boyle might have inspired the English physicist J. J. Thomson to propose the model for the structure of the atom after discovering the electron in 1897. E. A. DAVIS, I. J. FALCONER, 1997, MICHAEL HUNTER, EDWARD B. DAVIS (eds.), 1999–2000, vol 2.2.

9 Although not financially viable, modern science could make the alchemists' dream a reality. What is needed is to remove one proton from mercury (which has 80) or add one proton to platinum (which has 78) and gold (79) will be the result. However, adding or removing protons requires a nuclear reaction and cannot be achieved by a chemical operation.

10 The initial substance was usually subjected to fire, i.e. "killed" and this process was often portrayed as leaving a dismembered or decayed body. DAN BURTON, DAVID GRANDY, 2004, 83.

11 The *Nomenclature* section in this paper reflects how the names of the same substances changed from region to region or from one recipe to the next.

12 Alchemy was considered to be an art, and "art" features in numerous tractates, e.g. *Ars chimica*, Strasbourg, 1566; or, during the medieval and Renaissance period, the descriptor "art" did not refer to fine art only, but was a designation for various trades, as in *arti minori* and *arti maggiori* of the Florentine guild members.

13 In some instances, the emphasis is on the alchemist as the "perfecter" of nature's imperfections. JOLANDE JACOBI (ed.), 1951, 92–93.

14 Other museums have also staged exhibitions with such titles as: *The Alchemy of Paint* (The Fitzwilliam Museum Cambridge, 2009), *Alchemy* (Max Planck Institute for the History of Science, Düsseldorf, 2014), *Alchemy*, *The Great Art* (Getty Research Institute, 2017), *Art and Alchemy* (Kulturforum, Berlin, 2017), *Transmutations: Alchemy in Art* (The Chester G. Fisher Gallery at the Chemical Heritage Foundation, Philadelphia, PA, ongoing exhibition), *Exhibition of Alchemy* (Alchemy Museum, Rosicrucian Park, San Jose, CA, ongoing exhibition).

15 The two manuscripts from this period, *Splendor Solis (*1532–1535) and the *Ripley Scrolls* (15th century) are representatives of such a body of complex imagery. Both illustrate symbolic alchemical processes of death and rebirth following the lavish tradition of manuscript illumination of the previous centuries. More "modern" examples include, among many, Rebecca Horn's *The chemical wedding*, a glass reservoir half filled with blue water with a quotation from Johann Valentin Andreae's novel (1616) *The Chymical Wedding of Christian Rosencreutz, anno 1459*, printed on top, or Herbert Silberer's images based upon alchemical concepts constructed on psycho-analytical interpretations akin to Jung's, or surrealist writer André Breton and sculptor Anish Kapoor.

16 JOHN HENRY, 1990, 587. However, it must be noted that for Teniers, as for Brueghel, alchemical scenes were less numerous than in other genre paintings destined or commissioned for an increasingly wealthy bourgeois audience. PETER J. T. MORRIS, 2015, 23.

17 Shakespeare's England, likewise, did not hold alchemists in high esteem, considering the satirical play *The Alchemist*, written by Ben Jonson and staged at the Globe Theatre in 1610. Jonson's character Subtle was possibly modeled upon the Elizabethan astrologer, alchemist and herbalist Simon Forman (1552–1611).

18 TARA NUMMEDAL, 2007, 6. While there might have been many rogues and tricksters among the alchemists, recent research has unearthed many whose inquiry into the nature of the world was genuine and for whom matter and its transformation were closely associated with man and his spiritual life. See LAWRENCE M. PRINCIPE, 2011, 305–312.

19 WILLIAM EAMON, 1994, 114–115.

20 Ibid.

21 Paracelsus published *Der grossen Wundartzney* (The Great Surgery Book) in 1536: CHARLES WEBSTER, 2008.

22 PAMELA H. SMITH, 2004, note 36, 141, 142.

23 OWEN HANNAWAY, 1986, 585; PETER J. T. MORRIS, 2015, 19–24.

24 PAMELA H. SMITH, 2016, 299; URSULA KLEIN, 2009, 769–782.

25 OWEN HANNAWAY, 1986, 590; WILLIAM R. NEWMAN,1999, 59–77.

26 https://www.mpiwg-berlin.mpg.de/en/research/projects/fg_dupre_uffizigallery (April 15, 2017).

27 Translated from the *Aureum Vellus oder Guldin Schatz und Kunstkammer* (The Golden Fleece, 1598–1599), JULIUS KHON, London, 1920 (appendix).

28 The various copies of the manuscript are known by its two most common titles: *Schedula diversarum artium* (List of various arts), often cited as *Schedula* for short, and *De diversis artibus* (On various arts).

29 See entry on Theophilus and his *Prologues*.

30 LAWRENCE M. PRINCIPE, 2013, 69.

31 Ibid.

32 The most comprehensive drawings can be found in ANDREAS LIBAVIUS, *Alchymia*, Frankfurt, 1606; also woodcuts of Jost Amman (c.1539–1591) depicting various trades. Illustration of various laboratory vessels. URL= http://www.alchemywebsite.com/Equipment_Libavius_Alchymia04.html (May 18, 2017).

33 The name is derived from Arabic *at-tannūr,* but also called *Piger Hernicus, i.e.* philosophical furnace, PETER J. T. MORRIS, 2015, 25.

34 These images were not portraits of serious adepts pursuing the art of alchemy, but more like Chaucer's Canon Yeoman ... *whose over cote is not worthe a myte ... it is filthy and to-tore*. Chaucer was well acquainted with alchemy and describes the Yeoman as once a happy man clad in fine clothing who, due to his pursuit of alchemy, had become impoverished and mortally ill (likely from lead poisoning). THEODORE ZIOLKOWSKI, 2015, chapter II. 48.

35 Judging from his name, a certain Michael Puff von Schrick of Vienna (1400[?]–1473) evidently belonged to this group. JOHN READ, 1995, 79. In these paintings, depiction of laboratory equipment should not be taken at face value, as its size and prominence was often exaggerated for a desired effect.

36 Lavishly illuminated alchemical manuscripts like *Splendor Solis* would hardly be consulted in grimy environments such as those depicted in paintings of alchemists' laboratories.

37 Alchemists' own drawings, such as those in the 17th-century text *Mutus Liber* (La Rochelle, 1677), tended to be more allegorical than factual, possibly also willfully secretive. The German scientist Georgius Agricola's *De Re Metallica* (1556) is probably the first reliable guide to early laboratory techniques such as the handling of strong acids. In later illustrations, the furnace shrinks, then disappears entirely, and tables and benches appear. PETER J. T. MORRIS, 2015, 26–27, 39–42; see also PAMELA H. SMITH, 2006, 210–233, 290–305.

38 Ceration is the conversion of substances into a doughy mass or into a fusible solid. PETER M. HOLT, ANN K. S. LAMBTON, BERNARD LEWIS, 1970, 777.

39 WILLIAM R. NEWMAN, 2006, 513.

40 An exposition upon Sir George Ripley's Vision written by Aeyrenaeus Philalethes, Anglus, Cosmopolita, London, 1677. Quoted in STANISLAS KLOSSOWSKI DE ROLA, 1973, 24.

41 CHARLES S. THOMPSON, 2002, 68–76.

42 *Because of your fermentation or cibation...* exclaims a character in Ben Jonson's play *The Alchemist,* HELEN OSTOVICH, 2013, 388.

43 Quoted by THEODORE KIRKRINGUS, 1678, URL = http://www.sacred-texts.com/alc/antimony.htm (May 15, 2016); FRANCIS BARRETT, 1815, 233.

44 BARBARA DIBERNARD, 1977, 274–289.

45 GEORGE RIPLEY, 1591.

46 CHARLES J. S. THOMPSON, 1897, 68.

47 *... augment medicines in each degree, / In color, in odor, in vertue and also in quantitee*. STANTON J. LINDEN, 2003, 18.

48 Again Ben Jonson makes fun of the process and calls for those present to *Get you your stuff here against afternoon, / Your brass, your pewter, and your andirons* so you could have them turn into *gold*. HELEN OSTOVICH, 2013, 388.

49 TARA E. NUMMEDAL, 2007, 171.

50 HEIDI C. GEARHART, 2010, Diagram 1, 331.

51 MICHAEL BAXANDALL, 1972, 14–16.

52 ANDREAS SPEER, HILTRUD WESTERMANN-ANGERHAUSEN, 2006, 249–258.

53 This is evident from the Vienna manuscript, the Brussels manuscript, and the collection of Jean le Bègue, as all suggest an interest in artistic techniques, while the Wolfenbüttel manuscript, the Cambridge, Egerton, and Leipzig manuscripts, and Paris 1422 seem to imply that Theophilus was read as a source of knowledge of the natural world. HEIDI C. GEARHART, 2010, 131.

54 *Est autem alchimia operativa et practica quae docet facere metalla nobilia et colores et alia multa melius et copiosus per artificium, quam per naturam fiant*. Quoted by WILLIAM R. NEWMAN, JEREMIAH HACKETT (eds.), 1997, 318, Brill, 1996, note 4, 318.

55 By giving the recipe the title *Spanish gold*, Theophilus clearly refers to Arabic alchemical practices, further supported in the text by mention that the ingredients in the recipe derive from the *knowledgeable heathens* (my italics). THEOPHILUS 1963, 119, note 1. The Islamic rule of the Iberian peninsula lasted for

varying periods until the fall of Granada (1492). CHET VAN DUZER, 2014, 369–378.

56 MARY P. MERRIFIELD, 1849, 59, recipe no. 26; E. R. CALEY, 2008, 1152, recipe no. 8.

57 LAWRENCE M. PRINCIPE, Chicago, 2013, 22. Some late antique coins imitating precious metals have been discovered: their metallurgical analysis supposedly follows similar recipes mentioned in two Egyptian papyri, PAUL T. KEYSER, 1995, 209–33. For Egyptian papyri see E. R. CALEY, 1927, 979–1002; E. R. CALEY, 1926, 1149–1166.

58 In England, Sir John Lovel (c. 1288–1314) began minting coins with lesser amounts of silver, and legislation in 1299 outlawed their use. In some instances, to strengthen the amount of coin in circulation, rulers opted to replace debased silver with gold coinage, only to have it hoarded and substituted with alchemists' fakes. King Edward III (1327–1377) of England took into his service two alchemists, hoping that they would do *much good* for the country. (The reports do not tell us whether they succeeded.)

59 TARA NUMMEDAL, 2007, 151–152.

60 ibid, 150.

61 ARTHUR EDWARD WAITE, London, 1893, 137.

62 Ibid.

63 Nicolas Eymeric (1320–1399) was the principal inquisitor for the Crown of Aragon, the author of the well-known *Directorium Inquisitorium*; he also wrote a dissertation *Contra alchimistas*, considering them not only fraudulent but, above all, in league with the Devil and therefore heretical. CHIARA CRISCIANI, MICHAELA PEREIRA, 1996, 253.

64 Theophilus' awareness of potential mistakes and how to correct them suggests that he had a mastery of many productions. Likewise Theophilus' reference to Regalia Benedicti: *-ora et labora*, the virtue of working with one's hands -shows his awareness of Benedictine rules. C. R. DODWELL, 1961, introduction; HERBERT APPLEBAUM, 1992, 239–241.

65 WILFRED R. THEISE, 1995, 242.

66 VICTOR CAMERON, 1878, 159.

67 WILFRED R. THEISE, 1995, 251.

68 MARIE-LOUISE VON FRANZ, 1966, X-XII.

69 WILFRED R. THEISE, 1995, 248. Herman of Carinthia, also nicknamed Hermannus Dalmata, or Sclavus Secundus, was an Istrian philosopher, astronomer, astrologer, mathematician, translator and author. Born 1100 on the island of Korčula (Corcyra Nigra), died 1160, Herman is, among few others, the most important translator of Arabic astronomical works and popularizer of Arabic culture in Europe. The influence of his translations on the development of medieval European astronomy was especially large. SHEILA LOW-BEER, 1979.

70 See commentary on appended texts to Theophilus' *Schedula*, note 3.

71 PEARL KIBRE, 1980, 187–202; JOHN MARENBON, 1998, 188.

72 LUCA BIANCHI (ed.), 2011.

73 WILLIAM R. NEWMAN, ANTHONY GRAFTON (eds.), 2001, 8.

74 Sun (gold), Moon (silver), Mercury (quicksilver), Venus (copper), Mars (iron), Jupiter (tin), Saturn (lead).

75 *That which is above is like that which is below and that which is below is like that which is above, to accomplish the miracles of one thing. And as in all things whereby contemplation of one, so in all things arose from this one thing by a single act of adoption.* Quoted by SAMUEL C. THOMPSON, 2002, 31–35. See also KEVIN VAN BLADEL, 2009. Hermes Trismegistus is always recognizable by his clothing, and Michael Maier in *Symbola Aurea Mensae* (1617) shows him pointing towards the twin Principles of the *Magnus opus*: sulfur and mercury, whose father and mother are the Sun and the Moon, portrayed in a fiery embrace of the Sacred Fire. The astrolabe in his hand represents the necessity of a mysterious cosmic agent before the Subject of the Wise can become the Philosopher's Stone. MICHAEL MAIER, *Atlanta fugiens*, Oppenheim, J. Th. de Bry, 1618.

76 *...they have given it (Magnum opus) the names of all kinds of things*. MARTINUS RULANDUS, n.d., 225.

77 GABRIELE MINO, 1997, 143–165. There is philosophical and religious context to alchemy that goes deeper into the concepts of a belief in self-proven principles of the universe, of "perfectibility" regarding a union of spirit and body of *hieros gamos*, also referred to as alchemical marriage. Also in ARTHUR EDWARD WAITE, 1999, 236: *...celestial and terrestrial influences are necessary for a successful outcome of transmutation*.

78 MARTINUS RULANDUS, n.d., 5.

79 LAWRENCE PRINCIPE, 2012, 44. Jabir's Latinized name was Geber, which in turn was used in Pseudo-Geber, for an anonymous alchemist of the 13th century, sometimes identified as Paul of Taranto. WILLIAM R. NEWMAN, 1985, 79–90.

80 It is difficult not to make a parallel with the initial discovery of nuclear weapons, conducted in secrecy lest they fall into the '"wrong" hands.

81 JANE PEARSON, HEW D. V. PRENDERGAST, 2001, 475; DANIEL V. THOMPSON, 1956, 124.

82 PHILIP BALL, 2001; VICTORIA FINLAY, 2002, JOHN GAGE, 1990; SPIKE BUCKLOW, 2009.

83 The first decades of the 18th century are considered to mark the break of chemistry with alchemy, the two taking separate paths with diverse goals. Lavoisier (1743–1794) is considered to be an early exponent of modern chemistry for changing it from a qualitative to a quantitative activity by carefully measuring ingredients used in experiments and insisting on validating tests by workable re-runs. He also regularized chemical nomenclature.

84 For each of these pigments a comprehensive history, literature and chemical composition is given. NICHOLAS EASTAUGH, VALENTINE WALSH, TRACEY CHAPLIN, RUTH SIDDALL, 2008, lead white 240, minium 264, verdigris 391 and vermilion 393.

85 Vasari obviously did not read Cennini carefully, as in the *Vita di Agnolo Gaddi* he states that Cennini does not mention *rosso cinabrese*.

86 CENNINO CENNINI, 1960, 36–39, 101–102. Purpurina, or mosaic gold, is principally made from quicksilver, tin and sal ammoniac, prime materials of alchemists. Bersch lists several formulae for making ersatz gold which are very similar to early recipes found in ancient treatises: tin filings, sublimated sulfur

(*sulphrum vivum*) and ammonium chloride (*sal ammoniac*). In some recipes mercury is suggested, since it promotes a more immediate bonding of base metals to sulfur. JOSEPH BERSCH, Vienna, Leipzig, 1902., 163.

87 DANIEL V. THOMPSON, 1956, 33.

88 Ibid, note 69, 95.

89 CENNINO CENNINI, 1859, LVI, 35.

90 JOSEPH NEEDHAM, Cambridge, 1974, 23.

91 Minium, was often called cinnabar and was used to adulterate the much more valuable vermilion. JOHN BOSTOCK, 1828, 56.

92 SPIKE BUCKLOW, 2014, 16–41.

93 Three men fasted in the desert for forty days: Moses (Exodus 34:27-28), Elijah (1Kings 19:8), and Jesus (Matthew 4:2). The Flood lasted for forty days (Genesis 7:12 and also embalming [Gen 50:3]). These are just a few of many examples.

94 GAETANO & CARLO MILANESI, 1859, 49.

95 MARY P. MERRIFIELD, 1967, vol. I, clxi.

96 GIORGIA AGRESTI, 2013, table 52, 189.

97 CLAUDIO SECCARONI, 2006.

98 GIORGIA AGRESTI, 2013, 190.

99 DANIEL V. THOMPSON, 1956, 81. The only ancient formula for preparing *giallorino* is mentioned in Bologna MS, recipe 194.

100 GIORGIA AGRESTI, 2013, table 52, 189.

101 S. BOGOVIC-ZESKOSKI, 2015, 51–58.

102 A number of pigment-supplying companies refer to the yellowish pigment as massicot/litharge as if one and the same; for example: Kremer catalogue of Pigments.

103 SPIKE BUCKLOW, 1999, 140–149.

104 THEOPHRASTUS, 1965.

105 JOHN ERIC HOLMYARD, 1931, 60.

106 URSULA KLEIN, E. C. SPARY, 2009, 39; ARI WALLERT, 1989, 155–6 suggests that the preparation of vermilion was known in the West even before the translation of Jabir's texts.

107 RUTHERFORD J. GETTENS, GEORGE L. STOUT, 1966, 171.

108 SPIKE BUCKLOW, 1999, 110.

109 DANIEL V. THOMPSON Jr., 1954, 24.

110 CENNINO CENNINI, *Della natura del rosso*, XL, 1859, 30. This is an additional reference that pigments could be procured from friars, who most likely also made them.

111 THEOPHILUS, 1966, 40, Caput XXXVI. De cenobrio: "Si desidero cinobrium tolles sulphur, cujus sunt tris genera, nigrum et croceum, quod frangene super lapide siccum, adde ei duas partes vivi agenti sequo pondere staterae; et cum diligentius miscueris, mitte in vitream ampullam, cooperiens eam ex omni omi parte argillà, et os obstrue, ne fumus exeat, et pone eam ad ignem ut siccetur. Deinde pone eam inter carbones ardentes, et mox cum coeperit calefieri, audies fragorem interius, quomodo se vivum argentum commiscet ardenti sulphuri; et cum sonus cessaverit, statim ejice ampullam et aperiens tolle colorem." ROBERT HENDRIE, 1847, 44.

112 PLINY THE ELDER, 2014, book XXXIII; JOYCE IRENE WHALLEY, 1982, 137; DANIEL V. THOMPSON, 1954, 103.

113 It is made by heating together silica, copper alloy filings or a copper ore such as malachite, lime (calcium oxide) and an alkali such as potash or natron. LORNA LEE, STEPHEN QUIRKE, vol. 1, 2000, 108–11. VITRUVIUS, 1970, VII, XI, I, gives similar ingredients: sand, copper filings and nitrum. F.GRANGER, 1970, 123–4.

114 PAUL T. NICHOLSON, JULIAN HENDERSON, 2000, 199–202.

115 BARBARA H. BERRIE, 2007, vol. 4, 39, 109. *Caput mortum* is sometimes used as an alternative name for "mummy brown," a pigment that was originally made in the 16th and 17th centuries from ground-up Egyptian mummies. SPIKE BUCKLOW, 2009, 37.

116 For additional discussion on nomenclature see JOHN GAGE, 1990, 94–97. For example Mark Clarke, 2001, mentions: *azurium, meaning red vermilion* (Appendix: Subject Index to the Contents of the Manuscripts).

117 JOHN GAGE, 1999, 92; see also RICHARD W. HUNT, MARGARET GIBSON, 1984, 1–18.

118 JOHN GAGE, 1990, 93.

119 CENNINO CENNINI, 1954, 23.

120 SREBRENKA BOGOVIC-ZESKOSKI, 2015, 51–58.

121 The Papyrus Graecus Holmiensis, which is also known as the Stockholm Papyrus, dates from c. 300 AD and contains craft recipes written in Demotic Greek. The Leyden papyrus X derives from the same (or very similar) sources. EARLE RADCLIFFE CALEY (ed.), 2008. See also S. BOGOVIC ZESKOSKI, 2015, for an additional list of manuscripts.

122 The author suggests, as a possible source, a manuscript attributed to an Arab alchemist active in Sicily. The manuscript contains a recipe which calls for ashes of basilisk. CHET VAN DUZER, 2014, note 9, 371.

123 There is only one other "strange" recipe in the manuscript; it calls for goat's blood to soften a precious stone, thus facilitating its carving. THEOPHILUS, 1979, 189–190.

124 *De auro Hyspanico*, XLVIII: "Est etiam aurum quod dicitur Hyspanicum, quod conficitur ex rubeo cupro et pulvere basilisci et sangue humano atque aceto. Gentiles (Heathen?) enim, quorum peritia in hac arte (parte) probabilis est, creant sibi basiliscos hoc modo. Habent sub terra domum superius et inferius et omni parte lapideam, cum duabus fenestellis tam breuibus ut uix aliquid luminis appareat per eas; in quam ponunt duos gallos ueteres duodecimi aut quindecimi annorum, et dant eis sufficientem cibum. Qui cum incrassati fuerint, ex calore pinguedinis conueniunt inter se, et ponuant oua. Quibus posits, eiciuntur galli et imittuntur bufones, qui oua foueant, quibus datur panis in cibum. Fotis autem ouis egrediuntur pulli masculi sicut pulli gallinarum, quibus post dies septem crescuntcaudae serpentium, styatimque, si non esset, pauimentum domus lapideum, terram intrarent. Quod cauenteseorum magistri habent uasa aenea rotunda magnae amplitudinis, ex omni perforata, quorum ora sunt conscricta, quibusimponunt ipsos pullos et obstruunt ora cupreis cooperculis atque sub terra infodiunt, et ingrediente subtili terra per foramina nutriuntur sex mensibus. Post haec discooperiunt et copiosum ignem apponunt donec bestiae interius omnino comburantur. Quo facto cum refrigeratum fuerit, eiciunt et diligenter terunt, addentes ei tertiam partem sanguinis hominis rufi, qui sanguis exsiccatus et tritus erit. Haec duo composita temperantur

aceto acriin uase mundo; deinde accipiunt tenuissimas tabulas rubei cupri purissimi, et super eas liniunt hanc confectionem ex utraque parte atquer mittunt in ignem. Cumque canduerit extrahunt, et in eadem confectione extingunt et lauant, sicque tamdiu faciunt, donec ipsa confectio cuprum transmordeat, et inde pondus et colorem auri suscipiat. Hoc aurum omnibus operibus aptum est." R. C. DODWELL, 1961, 96–98.

125 THEOPHILUS, 1963, note 1, 119.

126 Ibid.

127 MARK CLARKE, 2011, 15.

128 Ibid, 50.

129 Ibid, 16.

130 LAURENCE A. BREINER, 1979, 30–46; MALCOLM SOUTH (ed.), 1987, 113–122.

131 DANIEL T. RODGERS, BHAVANI RAMAN, HELMUT REIMITZ (eds.), 2014, 115.

132 WILLIAM EAMON, 1994, 114.

133 ALBERTUS MAGNUS, 1916, 1496; also CHET VAN DUZER, 2014, 375, note 26.

134 PETER COSTELLO, 1979, 37.

135 LAWRENCE PRINCIPE, 2012, 54. See also CHET VAN DUZER, 2014, note 6, 371.

136 SPIKE BUCKLOW, 2010, 20.

137 Reference given by van Deusen about Abufalah's manuscript can be found in R. PATAI, 1999, 235–244.

138 The identification of basilisk ash with mercury was suggested by ARI WALLERT, 1989, 154–161; the identification of the blood of a red-haired man with sulfur (or mercury) was suggested by MARTINUS RULANDUS, Kessinger, n.d. and SPIKE BUCKLOW, 2009, 99–104.

139 THEOPHILUS, 1963, Ch. 95, 189–190. The gem is heated by a live goat's blood; a hole is cut between breast and stomach and the gem is inserted; it *can be carved while the heat lasts*.

140 Quoted in URSULA KLEIN, E. C. SPARY, 2009, note 54, 43. See also note 55, 43–44 for additional recipes which call for human blood.

141 BRUCE T. MORAN, 2005, 10.

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Sažetak

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POVIJESNI PIGMENTI I ULOGA ALKEMIJE U NJIHOVOJ PROIZVODNJI: INTERDISCIPLINARNA STUDIJA

Studija sustavno preispituje može li sveobuhvatno saznanje o dostignućima alkemije učinkovito utjecati na kvalitetniji pristup očuvanju kulturne baštine i pridonijeti uspješnijem restauriranju umjetničkih djela. Alkemičari i umjetnici oslanjali su se na različite obrtničke prakse (metalurgija, staklarstvo, keramika itd.). Boja im postaje poveznica: umjetnici bojom prikazuju svoje kreativne vještine, alkemičari prepoznaju i utvrđuju ishod svojih eksperimenata. Stoga nije neobično da alkemijski recepti u brojnim rukopisima iz predmodernog razdoblja, osobito iz srednjovjekovlja, sadrže relevantne informacije o umjetničkim materijalima i često se s alkemijskim traktatima nalaze uvezani u isti korpus. Mnogi od zabilježenih pokusa zorno prikazuju da su alkemičari pomno promatrali i analizirali razne procese, pretvorbe i sinteze tvari te dobivene rezultate preispitivali i bilježili. Zapadnjačka alkemija doživjela je zamah u Europi u srednjem vijeku, uvelike zahvaljujući prijevodima arapskih tekstova u kojima je sačuvana znanost drevnog Egipta i antičke Grčke. Tijekom 12. stoljeća većina alkemijskih dostignuća stigla je na Zapad uglavnom preko Bliskog istoka i Španjolske, a zapisi o tim alkemijskim novostima uspješno su prevođeni na latinski jezik. Pokušaj pretvaranja neplemenitih kovina u zlato i srebro te traženje eliksira života proizašli su iz okultne naravi alkemijske znanosti. Načela te okultne proto-znanosti kojima se eksperimentalna praksa vodila bila su promjena nečistog u čisto, jednostavnog u složenije, te put od neznanja do spoznaje svijeta. U tom nastojanju alkemičari su stvorili osnovu za mnoge suvremene ideje te otkrili važne kemijske procese i sastojke. Među alkemijskim zapisima postoje i tekstovi s praktičnim uputama i receptima, kao što je priprema različitih pigmenata. Od velikog broja traktata o toj temi, za detaljniju analizu izabrani su rukopisi Teofila Prezbitera i Cennina Cenninija. Cennini u svojoj „Knjizi o umjetnosti" za neke pigmente, poput cinobera, olovne bijele ili olovne crvene, orpimenta i verdigrisa, bilježi da su stvoreni „alkemijski", dok su drugi, poput lakove crvene i *giallorina*, dobiveni umjetnim putem, ali ne uz pomoć *chymie* (preferirani temin današnjih znanstvenika). Cenninijeva prosudba o naravi pigmenata nedvojbeno upućuje na čvrste poveznice između alkemičara, alkemijskih tekstova i proizvodnje slikarskih materijala. Teofilov rukopis izabran je zato što citira alkemijski recept *par excellence* „Kako proizvesti španjolsko zlato", u kojem su tvari zadržale svoje okultne nazive, ali se uz znanje alkemijske nomenklature mogu transkribirati u izvedivi recept. Stoga je poželjno uspostaviti korelaciju između srednjovjekovnih i renesansnih traktata, te odrediti njihove vrijednosti za restauriranje umjetnina. Detaljno i točno objašnjenje procesa i sastojaka materijala važna je komponenta i odraz načina stvaranja pojedinih umjetničkih djela. Ako znamo sastav, lakše je pristupiti restauriranju, a ako znamo moguću strukturu, lakše je na umjetnini preciznije identificirati materijal. S tim u vezi treba uzeti u obzir i upute koje isprva djeluju nesuvislo, no jednom dešifrirane, čine važne informacije dostupnima. Poznavanjem alkemije, njezina jezika i načina razmišljanja suvremeni znanstvenik proširuje polje istraživanja, pa taj izvor ne samo da se ne smije zanemariti, nego zaslužuje daljnja, opsežnija istraživanja.

KLJUČNE RIJEČI: *alkemija, pigmenti, laboratorijska oprema, Teofil Prezbiter, Cenino Cennini, Hermes Trismegistus*